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A Regional Model of Agricultural Development

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I

Introduction

IN APRIL 1965 the UN Food and Agriculture Organization (FAO) published a study entitled "West African Pilot Study of Agricultural Development 1960–1975," the substance of which was discussed at an international meeting held at Dakar May 24–31, 1965. Essentially the study was an attempt to portray the agricultural economy of the West African region as it would be in 1975 if certain conditions were met. The most important of these related first to external factors over which the coun-

NOTE: The author participated as a consultant in the work on the FAO West African Pilot Study and is similarly participating in the work on its Indicative World Plan. The present paper is an individual contribution, however, and in no way commits the FAO to anything expressed therein. The author wishes however to thank the FAO for allowing the paper to be presented to the Econometric Society and for giving the author full access to material and to discussions with FAO officials. In particular the author gladly acknowledges a personal debt of gratitude to Mr. Louis Goreux of the FAO (now at IBRD) with whom much of the content of the paper has been jointly evolved. The West African study was published in English and French in two volumes with reference WIOA/W/AFR/65/1 and 2, and the report of the Dakar meeting was included in document CCP/65/14/2 presented to the thirty-eighth session of the Committee on Commodity Problems, FAO, Rome, June 1965. What in this paper are called regions are subregions in UN nomenclature.

tries embraced do not have complete control, such as the level of export earnings and the net inflow of foreign capital, including aid; and second to a target rate of growth of the gross regional product of 5 per cent per annum over the period 1960–75. By comparison of the projected picture for 1975 with the actual one for 1960, broad policy conclusions were drawn, which it was hoped would provide guidelines both for individual countries that are members of the region and for organizations responsible for considering regional development projects, including bilateral and multilateral aid-giving agencies. The study itself did not attempt the setting of targets for individual countries, although by grouping these into a number of "zones" within which ecological conditions are similar, it was possible to draw certain conclusions with strong implications concerning the growth and content of intraregional trade in agricultural commodities and of specialization in lines of agricultural production.

The projections and conclusions of the Pilot Study must therefore be considered as provisional in three important respects. First, since the technique was to treat the region as an economic unit and to discuss production and other balances, although disaggregated by commodities, at the level of the region or at most the zone, the regional picture presented in the study will remain viable only if individual national development plans are consistent with it and if the achievements of national economies are harmonious with each other. It may indeed turn out on closer investigation that the regional targets imply inconsistent or unrealistic behavior at the national level and that therefore a revision of the regional "indicative" plan is called for.

Second, the agricultural sectors and those closely dependent on them are dominant in the region, and although the remaining sectors were explicitly treated in the Pilot Study, they were not investigated in as great a detail as were the agricultural sectors. If false assumptions have been made about the remaining sectors in the study, there may again be a need to call for a revision of the study as a whole.

Third, the study was made in comparative isolation from the problems of the other developing regions of the world, some of which may compete to a greater or lesser extent in export markets and in the attraction of capital inflows from the developed countries. At the same time, the successful development of these other regions could lead to market opportunities for the West African region that have not been taken into account in the study. Thus some of the factors that have been treated as exogenous in the Pilot Study would become endogenous if similar exercises were undertaken for other developing regions, and the present

assumptions can be taken as a starting point only for a more general approach.

The FAO now in fact proposes to initiate such a general approach as part of its preparation for the Second World Food Congress to be held in 1968. About fourteen regional studies comparable to the Pilot Study for West Africa will be attempted, and the whole will be integrated within a world framework. The main purpose of this framework is to clarify the relations of the agricultural economies of the developing regions with the developed and centrally planned economies and to make sure that the assumptions on which the individual regional studies—especially in the areas of world trade and financial flows—are based, will be consistent.

The purpose of this paper is to set out in computable form the relationships involved in constructing regional projects as described above, taking the West African Pilot Study as the archetype. The second section of the paper is devoted to this task. Since, however, it is not deemed as important to record what was in fact done in the particular pilot study, as to set up what might become the core of future regional models, not all the individual complications of the West African model are included. In the third section of the paper a proposed world model is described in which the regions appear as the elementary units.

Before beginning this discussion, it will be useful to say a few words on the work procedures envisaged, since these have a close bearing on the design of the regional and world models.

The models are designed on the assumption that each regional study will be carried out by a small group of professionally trained people, including economists, nutritionists, and agronomists. Each study will occupy a group for five to six months, and it is expected that a maximum of four studies can proceed simultaneously. Thus, provision must be made for the adjustment of studies begun earlier in the sequence in the light of those began later. The world model will be used to set the basic assumptions for the first group of regional studies to be undertaken, and thereafter to serve as a guide in their continuous revision as the regional studies develop. In addition, the world model will be used in the study of variations in the principal assumptions, for example with regard to the projected magnitude and distribution of capital aid flows and to the total import requirements of the developed and centrally planned regions.

It should be mentioned that in parallel with the regional studies that are the subject matter of this paper, the FAO will undertake commodity studies at the world level, and provision must be made for feeding the results of these into the world model.

It will, therefore, be very useful to have both regional and world models designed as fully computable. In the regional models, however, though it will be necessary to use concepts such as import coefficients and capital-output ratios that are commonly treated as fixed parameters, it must be accepted that the detailed regional studies will be directed, at least in part, to discovering how far these coefficients may be modified in order to achieve the targets of the indicative plans and to meet anticipated stringencies in the external and domestic capital accounts. Furthermore, if a clear accounting framework is used and the general skeleton of the regional model is preserved, it may not be necessary or even useful to work with a model that may be programmed as a whole for an electronic computer. For the world model, on the other hand, it may be useful to have a computer program, since it may be necessary to run a quick investigation of the findings of the regional teams, and the basic model may serve with few modifications throughout the whole process.

II

The Regional Model

The Accounting Framework

In the West African Pilot Study extensive use was made of the accounting system developed by the Ministère de la Coopération, Paris, for use in the ex-French African territories. This system is described in detail in the series '*Planification en Afrique*.' [1] published by the same Ministry, and its principles have been compared with those of the United Nations Standard System by Ady and Courcier.[2] Basically it is an interlocking system of accounts, both real and financial, each divided into sources and uses (*ressources, emplois*), and therefore much more demanding of data than the basic accounts of the Standard System. There is no doubt, however, that something approaching the French system is necessary for development planning purposes and especially necessary for meeting the FAO criteria for individual agricultural commodity balances at the regional and world level. It is therefore interesting to note that the Economic and Social Council has prepared a set of proposals [3] for the

[1] *Planification en Afrique*, Volumes I–VIII, Ministère de la Coopération, Paris.
[2] *Systems of National Accounts in Africa*, OECD, Paris, 1961.
[3] A system of national accounts, proposals for the revision of SNA, 1952, UN Economic and Social Council E/ON. 3/320, Feb. 9, 1965. Cf. also adaptation of the proposed SNA for African countries, E/CN.14/NAC/20, UN/ECA, Addis Ababa, Jul. 5, 1965.

revision of the Standard System that go far to meet these needs. The system of accounts described in this paper is in line with the proposed revision.

The basic accounting matrix is given in Table 1. The subdivision of the main classes of accounts is designed to show separately in the table the explicit relationships between agriculture and the rest of economic activity. In the basic table, agriculture is aggregated in production, income/consumption, and capital accounts. Operationally this matrix is backed by a detailed subdivision into (a) monetary and nonmonetary activities, and within these into (b) the separate activities of crop production for regional and export purposes.

Most of the entries in the matrix are self-explanatory and require few comments. These are:

Agriculture production accounts. q_1 is the gross output of agriculture, of which f_{11} is the value of subsistence production, consisting mainly but not entirely of food; sales of agricultural products to other enterprises a_{12} and sales by other enterprises to agriculture a_{21} may not be separately known and may need to be entered net in the base year (an increase in a_{21} may, however, be a condition for raising agricultural productivity); gross investment in agricultural products by agriculture v_{12} includes both the stocking of agricultural commodities and "autoinvestment" by agricultural enterprises; exports outside the region x_{11} are defined as the f.o.b. value of unprocessed agriculture produce; a_{31}, inputs of public services into agriculture allow for the recording of productivity-raising extension services; a_{41} represents trading margins and y_{41} indirect taxes on agricultural products; m_{11} represents the c.i.f. value of imported current inputs such as pesticides and fertilizers.

Other enterprises production accounts. Exports x_{21} will include a component consisting of processed agricultural products, and it is necessary to know this separately.

The income/consumption accounts. The "incomings," r_{12} and r_{22}, from the external accounts represent earnings of regional enterprises located outside the region and remitted to it, while r_{42} represents the level of "current" or budgetary aid where this is relevant. In the "outgoings," the t entries represent, in row 3, the distribution of profits and subsidies to households, and in row 4, direct tax payments. (Subsidies to households t_{34} may be netted against taxes paid by households t_{43}.) Savings s are treated as gross—as no depreciation charges are made in the production

TABLE 1

Accounting Matrix for a Region

(all dollar figures in millions)

Accounts	Production				Income/consumption				Capital				External Goods		Totals
	Ag	OE	PS	OS	Ag	OE	Hh	G	GI	Ag	PuS	Prs	f.o.b.	Other	
Production															
Agriculture		a_{12}	0	0	f_{11}	0		f_{14}	0	v_{12}	0	0	x_{11}	0	q_1
Other enterprises	a_{21}		a_{23}	0	0	0	f_{23}	f_{24}	0	v_{22}	v_{23}	v_{24}	x_{21}	0	q_2
Public services	a_{31}	a_{32}	0	0	0	0	0	f_{34}	0	0	v_{33}	0	0	0	q_3
Other services	a_{41}	a_{42}	0	0	0	0	f_{43}	f_{44}	0	0	0	0	0	x_{42}	q_4
Income/consumption															
Agriculture	y_{11}	0	0	0	0	0	0	0					0	r_{12}	z_1
Other enterprises	0	y_{22}	0	0	0	0	0	0					0	r_{22}	z_2
Households	y_{31}	y_{32}	y_{33}	y_{34}	t_{31}	t_{32}	0	t_{34}					0	r_{32}	z_3
Government	y_{41}	y_{42}	0	y_{44}	t_{41}	t_{42}	t_{43}	0					0	r_{42}	z_4
Capital															
Gross investment					s_{11}	s_{12}	s_{13}	s_{14}	0	0	k_{13}	0	0	0	k_1
Agriculture					0	0	0	0	k_{21}	0	0	0	0	h_{22}	k_2
Public sector					0	0	0	0	k_{31}	0	0	0	0	h_{32}	k_3
Private sector					0	0	0	0	k_{41}	0	0	0	0	h_{42}	k_4
External															
Goods (c.i.f.)	m_{11}	m_{12}	m_{13}	m_{14}	0	0	n_{13}	n_{14}	0	w_{12}	w_{13}	w_{14}	0	0	e_1
Other	0	0	0	0	n_{21}	n_{22}	n_{23}	n_{24}	0	w_{22}	w_{23}	w_{24}	g_{21}	0	e_2
Totals	q_1	q_2	q_3	q_4	z_1	z_2	z_3	z_4	k_1	k_2	k_3	k_4	e_1	e_2	

accounts—and paid direct into a 'gross investment account' to overcome lack of information on the detailed flow of funds. Of the n entries, n_{13} and n_{14} represent the import of final goods used for private or public consumption, while the second row of n entries contains those that are the obverse of the r entries. This latter group of n entries can, if necessary, be netted against the r entries.

The capital accounts. Domestic savings are represented by the s entries, though it must be remembered that these contain a component r_{42} of current budgetary aid. Gross investment, including imported capital goods (row 1 of the w entries), is financed from domestic sources plus public aid routed through the public sector capital accounts after allowing for capital transfers abroad (row 2 of the w entries). These capital transfers include any repayments w_{23} of previous public aid receipts.

The external accounts. Here a somewhat unorthodox division is made between "goods" and "other," so that the trade gap g_{21} can be shown explicitly. If desirable and if the data exist, the other external account may be split between current and capital. In building up this account from country data the main difficulty is to net out intraregional trade and other flows. It will usually be necessary to construct separate matrices for these, so that they can be treated explicitly in the projection.

The Projection Model

If we write the corresponding capital letter to represent each submatrix in Table 1, the submatrix Y [4] for example is the matrix of income payments. The vector $i'Y$ (where i' is the row vector of units) consists of the income payments of agriculture and other enterprises, public and private services respectively; Yi represents the income receipts represented by the row totals of Y. The scalar quantity $i'Yi$ is the total of all income payments, or the gross regional product measured at market prices. We begin with a target value for this:

$$(1) \qquad i'_tYi = (1 + \rho)^N \, i'_0Yi, \text{ where } N = 15 \text{ years}$$

and where ρ is the target annual rate of growth of the gross regional product and ${}_0Y$ is the base year estimate of the submatrix Y. We have

[4] In the ensuing discussion, two-dimensional submatrices will be represented by unsubscribed capital letters which correspond to the letter found in the submatrix. One-dimensional vectors (occurring as "totals") will be represented by different unsubscribed lower-case letters where there is danger of confusion. Thus z represents the "totals" corresponding to Y and e represents those corresponding to X.

also the matrix ${}_tX$ given by exogenous analysis of world markets (this point is taken up in Section 3 of the paper).

If we knew the input-output coefficient matrices for the target year, which we shall denote by a bar over the symbol for the corresponding submatrix of Table 1, the equations for the production accounts would be

$$q = (I - \overline{A})^{-1}(F + V + X)i \tag{2}$$

$$M = \overline{M}q \tag{3}$$

$$Y = \overline{Y}q. \tag{4}$$

In the West African Pilot Study the initial estimates of the coefficient submatrices were constructed by a variety of means, including time-series and intercountry regressions. These were particularly useful for estimating target-year values of import coefficients and the relation between government and other sector incomes.

The coefficients of the input-output matrix $\overline{A}$ were mainly supplied by agronomists with a knowledge of the region, basing them on a general idea of the increase in outputs required. To fill in the vectors of final demand, first X is exogenously given. The demand equation,

$$F = L(Y) \tag{5}$$

was put in as linear relations with provisional coefficients, and V calculated from the scheme

$$V = \overline{V}\Delta q \tag{6}$$

$$\Delta q = (I - \overline{A})^{-1}(\Delta F + \Delta V + \Delta X)i \tag{7}$$

$$\Delta V = 0. \tag{8}$$

Of these equations the last is a simplification based on the assumption [5] of linear growth in final demand from the target year onwards; ΔF and ΔX were calculated analogously to F and X, and the coefficient matrix $\overline{V}$ based on preliminary capital-output ratios. The problem here is that imported capital goods appear in the submatrix W and therefore a provisional split must be made between imported and domestically produced capital goods. In the case of West Africa this was relatively easy, since it could be assumed that all plant, machinery and vehicles would continue to be imported during the planning period, so that domestic capital goods

[5] Cf. R. Stone and J. A. C. Brown, Output and investment for exponential growth in consumption, *Review of Economic Studies*, XXXIX, 80, 1962.

consisted mainly of construction, and of stock increases and autoinvestment in agriculture.

By such means the elements of the submatrices representing physical flows can be provisionally filled in, and by means of the estimated submatrix Y and estimates of the growth of income transfers to and from the region (the second column of R and the second row of N) the control vector z for the income/consumption accounts estimated. It should be mentioned that the trade gap g_{21} is implicitly estimated by this stage, since the imports of final consumption goods n_{13} and n_{14} are involved in the demand relations (5). These must be treated as the most flexible of imports in order to arrive at a permissible value for the gap g_{21}, since it is a condition of growth that most of the remaining import coefficients determining M and the first row of W will increase during the planning period. The remainder of the matrix is perhaps best considered under the headings of check calculations which are likely to cause revision of the estimates already arrived at above.

The Check on Sector Incomes

In the West African Study, which may be typical in this respect, agricultural exports were projected to increase at a rate less than the projected growth of the regional produce, and the demand equation used for agricultural products implied income elasticities less than unity. The rate of growth of gross agricultural output was therefore also less than that of the gross regional product, and the proportionate inputs from abroad and from other sectors rose as a function of the projected growth of agricultural output. Thus agricultural incomes necessarily rose at a slower rate than other regional incomes. It is necessary therefore to check that this process has not been allowed to proceed too fast, i.e. faster than the migration of population dependent on agriculture can reasonably be allowed for. In the West African case the most stringent control on this process was felt to be the required level of investment in social capital and infrastructure. To some extent the problem is alleviated by balance of payments considerations, since a policy of import substitution, necessary to check the growth of n_{13} and n_{14} increases the corresponding elements of F faster than the normal demand elasticities would imply. But since in developing countries there is not the scope that exists in developed countries for maintaining the relative incomes of the agricultural population by income transfer, subsidies or protection, the sector-income check is likely to place an upper limit on the projected rate of growth of the regional product.

The Savings and Taxation Checks

If direct taxation rates used to construct T by

$$T = \bar{T}z \tag{9}$$

are assumed unchanged from the base year, the domestic savings in S are obtained as residuals in completing the income/consumption column of submatrices F, T, S and N. The implied saving ratios can then be calculated from

$$\bar{s}_{1j} = s_{1j}/z_j, \quad j = 1, 2, 3, 4 \tag{10}$$

and examined for realism. This of course is not the end of the story since domestic savings with foreign capital inflows must finance the investment program represented in V and W. Anticipating this, and assuming for example that the savings estimates are too low, either imports of final goods or final demand F must be squeezed, and in doing this, account must be taken of sectoral income ratios and the trade gap g_{21}. Pressure will be placed on the taxation ratios of the fourth row of T in the attempt to finance expanded government programs, and the elements of T and S will be in a competitive relationship. In the West African study considerable use was made of intercountry comparisons to determine feasible upper limits to both taxation and savings rates.

The Check on the External Balance

In the second row of W are the capital transfers out of the region, w_{22} and w_{24} relating to transfers made by foreign enterprises (assuming that investments made abroad by domestic enterprises are small) which must be estimated as trends, and w_{23} relates to public transfers which will be largely a function of public loan receipts up to the terminal year of the plan and their repayment arrangements. Similarly h_{22} and h_{42} represent new investments in the region by foreign enterprises, and an assumption must be made as to the extent it is desirable and possible to attract such investments. Public aid h_{32} then appears as the final balancing item and a measure of the ultimate difficulty of achieving the plan targets. This is arranged in the matrix since the balancing item in the savings row is k_{18}, routed through the public accounts, which is merely an accounting device to overcome the deficiency of flow-of-funds information and the difficulties of projecting such flows in detail, whilst these are not essential to the primary purposes of the projection. Once again an unacceptable

level of h_{32} implies a fairly fundamental revision of the original provisional projection.

Disaggregation of Agriculture by Commodities

The purpose of constructing the estimated accounting matrix for the base and target year is to provide a control framework, both current and capital, and domestic and external, within which a more detailed study can be made of the agricultural sector and those other sectors closely associated with it.

The main instrument used for this more detailed study in the West African case was the individual commodity balance, and the work was done mainly by agronomists. In the West African study some twenty commodities were treated individually. On the uses side of the account, exports were evaluated by commodity specialists, the direct demand for agricultural products for final consumption by demand equations, and the demand for agricultural products for intermediate use by input-output coefficients. The demand equations were estimated from cross-section and time-series analysis, and with regard to the equations for foods these were checked by computing the aggregate calorific and protein values and the farm-gate value of total consumption. These are very necessary checks in a projection covering fifteen years, and of course are also used by the nutritionist who may wish to achieve a different dietary pattern from that projected on the assumption of free demand at constant base year prices. These modifications of the diet may be achieved by direct means, such as import control, or by use of changes in relative prices, or by educational measures. On the supply side the problem is to balance regional production and imports within the aggregates given in the accounting matrix. In the West African case the limiting factor for regional production was not normally land except for a few cases of specialized crops and livestock production, but more usually the investment required to raise output and the scarce factor of skill to operate more productive techniques. This latter scarce factor is also controlled to a large extent by the allocations made in the accounting matrix for public investment and current outlays on extension services, together with the physical limits of the build-up of trained extension staff at all levels.

At this level of disaggregation, little use was made of simple capital-output ratios based on past performances, but more reliance was placed on best-practice techniques in the regional context. An important factor in determining the capital-output ratios, *ex post,* as it were, is the policy

decision for the individual crop as to the extent output should be raised by intensive (increases in fertilizer or pesticide) as opposed to extensive (increases in acreages) methods. Formally the latter would give rise to increases in investment in the accounting matrix V whereas the former would be reflected in increases in current input coefficients $\overline{A}$.

Although the process has been described as though all detailed work were made to conform with the original constraints of the accounting matrix, such detailed work also gives rise to the need for revision of the original matrix, and the processes described above (derivation of the projection model together with the three checks) must be repeated if necessary, though it is hoped that these adjustments would be marginal and relatively easy to make.

Disaggregation by Zones

This process represents an intermediate stage on the way to disaggregation by countries, and the zones were chosen in the West African study to bring out marked differences in the agricultural economies. In principle each zone is a subgroup of countries with strong similarities in ecology and consequentially in dietary habits. There is of course the possibility that each zone should be equipped with a full accounting matrix, and a similar process to that described for the region repeated. The main reason against this is that the ecological grouping is appropriate for the agricultural sector but not necessarily so for the other sectors; also the problem of completely balancing the other sectors at the zonal level becomes increasingly difficult without expertise in industrial projects and without considering interzonal flows of manufactured goods and payments. In the West African study therefore the zonal disaggregation was confined to the agricultural sector, and the treatment was entirely in terms of physical commodity balances. Thus a number of questions were left open. For example, with regard to cotton, the confrontation in the commodity balances of zonal production plans with zonal demands for cotton products gave rise to projected flows of cotton between zones, but it was left open as to whether the cotton would move in raw form or as embodied in textile products, according as to the siting of the processing industries.

The main points then revealed by the zonal disaggregation were: first, the projected structure of agricultural production, particularly as regards the balance between the production of export crops destined for outside the region and the production of food and raw material production for consumption within the region; second, the relative rates of

growth of agricultural incomes in each zone; and third, orders of magnitude of interzonal flows in agricultural commodities which would provide a first step towards the evaluation of the infrastructure investment required to sustain these flows. There remains of course the study of the zonal distribution of nonagricultural activities before a final conclusion of the viability of the Indicative Plan can be drawn. It is difficult to see how much further studies by international agencies alone could be taken, since the translation of an indicative regional plan into national policies would necessarily involve negotiation between the countries concerned and with aid-giving agencies. Nevertheless it might be hoped that an operational framework for such negotiations had been provided by the Indicative Plan, and that opportunities had been opened up for faster growth than would have taken place if studies had been made only at the national level.

III

The World Framework

The Accounting Matrix

As mentioned above in the Introduction the purpose of setting the regional studies in a world framework is primarily to achieve consistency between the individual studies and to introduce the key relationships between the developing world as a whole and the developed and centrally planned regions. It is not expected therefore that anything so ambitious as a "world growth model" could be attempted in the sense of a complete set of equations which could realistically simulate the development of the world economy or even of the agricultural sector. Even so, it is difficult to meet the minimum requirements of the world framework, and in many respects, formal completeness and elegance will have to give way before practical statistical difficulties. It is however useful to outline the minimum ideal matrix and operational procedures since, without a simple but firm system continually in mind, control of the regional work may easily be lost.

Table 2 sketches a matrix in which the developing regions are represented by regions 1 and 2, and the other regions by region A, which may be thought of as an aggregation of all those regions. The diagonal matrices represent the domestic flows within each region, and the symbolism is based on that of Table 1, so that the symbol a represents intersectoral flows, f final consumption, v gross investment, y gross income and s gross

TABLE 2

Sketch of a World Accounting Matrix

Accounts	Region 1				Region 2				Region A				Totals
	Agr.	Oth.	Income Consump.	Cap.	Agr.	Oth.	Income Consump.	Cap.	Agr.	Oth.	Income Consump.	Cap.	
Region 1													
Agriculture	–	a_{12}^{1}	f_{1}^{1}	v_{1}^{1}	–	x_{12}^{12}	x_{13}^{12}	–	–	x_{12}^{1A}	x_{13}^{1A}	–	q_{1}^{1}
Other	a_{21}^{1}	–	f_{2}^{1}	v_{2}^{1}	x_{21}^{12}	x_{22}^{12}	x_{23}^{12}	x_{24}^{12}	x_{21}^{1A}	x_{22}^{1A}	x_{23}^{1A}	x_{24}^{1A}	q_{2}^{1}
Income/consumption	y_{1}^{1}	y_{2}^{1}	–	–	–	–	y^{12}	–	–	–	y^{1A}	–	z^{1}
Capital	–	–	s^{1}	–	–	–	–	h^{12}	–	–	–	h^{1A}	k^{1}
Region 2													
Agriculture	–	x_{12}^{21}	x_{13}^{21}	–	–	a_{12}^{2}	f_{1}^{2}	v_{1}^{2}	–	x_{2}^{2A}	x_{13}^{2A}		q_{1}^{2}
Other	x_{21}^{21}	x_{22}^{21}	x_{23}^{21}	x_{24}^{21}	a_{21}^{2}	–	f_{2}^{2}	v_{2}^{2}	x_{21}^{2A}	x_{22}^{2A}	x_{23}^{2A}	x_{24}^{2A}	q_{2}^{2}
Income/consumption	–	–	y^{21}	–	y_{1}^{2}	y_{2}^{2}	–	–	–	–	y^{2A}	–	z^{2}
Capital	–	–	–	h^{21}	–	–	s^{2}	–	–	–	–	h^{2A}	k^{2}
Region A													
Agriculture	–	x_{12}^{A1}	x_{13}^{A1}		–	x_{12}^{A2}	x_{13}^{A2}	–	–	a_{12}^{A}	f_{1}^{A}	v_{1}^{A}	q_{1}^{A}
Other	x_{21}^{A1}	x_{22}^{A1}	x_{23}^{A1}	x_{24}^{A1}	x_{21}^{A2}	x_{22}^{A2}	x_{23}^{A2}	x_{24}^{A2}	a_{21}^{A}	–	f_{2}^{A}	v_{2}^{A}	q_{2}^{A}
Income/consumption	–	–	y^{A1}	–	–	–	y^{A2}	–	y_{1}^{A}	y_{2}^{A}	–	–	z^{A}
Capital	–	–	–	h^{A1}	–	–	–	h^{A2}	–	–	s^{A}	–	k^{A}
Totals	q_{1}^{1}	q_{2}^{1}	z^{1}	k^{1}	q_{1}^{2}	q_{2}^{2}	z^{2}	k^{2}	q_{1}^{A}	q_{2}^{A}	z^{A}	k^{A}	–

TABLE 3

Summary Notation for Table 2

	Region 1	Region 2	Region A	Totals
Region 1	T^{11}	T^{12}	T^{1A}	q^1
Region 2	T^{21}	T^{22}	T^{2A}	q^2
Region A	T^{A1}	T^{A2}	T^{AA}	q^A
Totals	q^1	q^2	q^A	–

savings. The region is denoted by the right superscript. The off-diagonal matrices accommodate trade flows and income and capital transfers between regions. The right superscripts here denote the pair of regions between which the flows take place (see Table 3).

In principle, the entries in such an accounting matrix can be filled in for a base year from national accounting and international trade data. There will be a number of statistical difficulties which will not be discussed here, and only two points will be made which will be useful in overcoming problems of data estimation. First, the accounts for countries represented by region A are required in the present exercise mainly for the flows between these countries and the developing regions.

This makes it possible to use simplifying devices, particularly in the diagonal submatrices for region A, which can overcome for example the differences in national accounting approaches of the developed and centrally planned countries. Second, unallocated flows may be handled by the introduction of a dummy region. This will help in handling the difficulties created by lack of complete knowledge of income and capital flows. We shall proceed for simplicity as though these problems have been completely overcome, and shall discuss the consistency model in terms of the three regions given in Table 2.

Procedure in the Consistency Model

We shall assume throughout the calculations as though the entries in the *columns* relating to region A are given for some target year. This means in particular that the import demands of region A from regions 1 and 2 are given, and also that the income transfers y^{iA} and capital transfers h^{iA} are given. This is not to preclude variations in these quantities, but at least in early experiments, it is best to seek for a solution in terms

of the columns relating to regions 1 and 2 on the basis of given columns for region A. Variations for example in h^{iA} may then be introduced as an act of policy designed to discover the variational effects. As in Section 2, a bar over a symbol will denote the input-output coefficient corresponding to the flow denoted by the symbol.

We shall treat the case of region 1 as that of a typical developing region. It would be possible to treat the block of developing regions together and there are some advantages in so doing. However, there are both computing and more general operational advantages in an iterative treatment which would converge under appropriate conditions to the same solution as the simultaneous process. The orders of vectors and matrices will be smaller, and since work on the regional models will proceed sequentially, it will often be the case that the results for some, at least, of the developing regions can be taken as given in addition to the relevant figures relating to region A. An asterisk written as a superscript to a variable vector or matrix will denote that the value is fixed in the above sense during the calculation.

The flow equation for the gross output *vector* $q^1 = q^1, q_2^1$ of region 1 can then be written

$$q^1 = \bar{A}q^1 + f^1 + v^1 + \bar{X}^{12}q^{2*} + X^{1A*}i \tag{11}$$

$$= \bar{A}q^1 + f^1 + v^1k^{1*} + \bar{X}^{12}q^{2*} + X^{1A*}i, \tag{12}$$

if k^{1*} be set approximately to achieve a desired rate of growth beyond the target year t. The problem is to obtain values for q^1 and f^1 in equation 11, which will be consistent with the target value of z^1, and achieve balance in the income and capital accounts. The main difficulty is likely to arise from the fact, as it did in the case of West Africa, that the target growth in income of region 1 is likely to be greater than the growth of the region's exports to region A, and if fixed import coefficients were used in matrix T^{A1}, the consequential imbalances will be greater than can be met by postulated income and capital transfers between region 1 and region A. Broadly, we can assume that the transfers y^{A1} and h^{A1} will be fairly rigid in the target year, since their levels will be determined by the past history of investments in region 1. Equally there will be little scope for downwards adjustment in x_{21}^{A1}, x_{12}^{A1}, and x_{22}^{A1}, since these represent current inputs of imported goods necessary to sustain the required growth of outputs, or of x_{24}^{A1}, since this represents the import of capital equipment. It must therefore mainly fall on x_{13}^{A1} and x_{23}^{A1}, imports of final agricultural and other goods respectively, to grow

less than proportionately to output and therefore to achieve the required balance in the external and capital accounts.

Let final consumption of agricultural and nonagricultural commodities therefore be linear functions of disposable regional incomes:

$$(13) \qquad f_1^1 + x_{13}^{21} + x_{13}^{A1} = \alpha_1^1 + \beta_1^1 \quad (z^{1*} - s^1 - y^{21*} - y^{A1*})$$

$$(14) \qquad f_2^1 + x_{23}^{21} + x_{23}^{A1} = \alpha_2^1 + \beta_2^1 \quad (z^{1*} - s^1 - y^{21*} - y^{A1*}).$$

Necessary regional savings are given by:

$$(15) \qquad s^1 = k^{1*} - h^{1A*} - \bar{h}^{12}k^{2*}$$

The totals of the left-hand sides of (13) and (14) are then determined.

If we take imports from region 2 as fixed, to simplify the argument, the split between the f and x^{A1} elements operates as follows: If x_{21}^{A1}, x_{12}^{A1} and x_{22}^{A1} are determined by input-output coefficients applied to q^1 and q^2, as x_{13}^{A1} and x_{23}^{A1} are reduced, f^1 and f^2 increase, and x_{21}^{A1}, x_{12}^{A1} and x_{22}^{A1} increase by less than the reduction of x_{13}^{A1} and x_{23}^{A1}. Beginning from values of x_{23}^{A1} which imply too large a value of the trade gap between regions 1 and A, therefore, reductions of imports of final goods will increase regional incomes z_1^1 and z_2^1 to a point where the implied trade gap is acceptable. This is not necessarily the level where the income accounts balance, namely where the computed values of z_1^1 and z_2^1 are consistent with the value of z^{1*} postulated in (13) and (14). The necessary adjustment must then be made in the propensities to import intermediate products.

Thus, what is envisaged is a calculation of final imports from region A, which, when added to the intermediate imports that are implied by these, fit the required total and an adjustment of intermediate import propensities in order to fit the postulated regional income targets. The mechanism for achieving this result has been deliberately left unspecified, since it is felt that experimental work is required before the most useful form of this mechanism can be worked out. It will however be useful to make such a mechanism algebraically precise, since it will be useful to be able to calculate the effect on the solution of varying such key variables as h^{1A}, the level of capital inflow from the developed and centrally planned economies.

In the foregoing discussion it may seem that the relations between regions 1 and 2 have been treated rather summarily. One reason for this is that the process described has been thought of as a single step in a multistage process, and it might eventually prove useful to operate with groups of developing regions simultaneously. The more important reason is that trade, income, and capital flows between most pairs of

developing regions are weak compared with similar flows between developing and region-A countries. The emphasis therefore of any policies of import substitution which may prove necessary has been placed more on intraregional than on interregional developments.

IV

Summary

The purpose of this paper is to outline the social accounting and model-building aspects of a large project which the FAO is undertaking. This project, for which some pilot study work was done, is aimed primarily at identifying the main policy problems for the agricultural sector of the developing world. As an important aspect of the role of the agricultural sector in the general economic development of these countries is its close relation with other economic activities, and as the relations, both of trade and aid, with the rest of the world set conditions for the general pattern of development, the writer has suggested a simple accounting framework for use at both the regional and world levels. The regional accounting frame and its associated projection model is designed to provide a discipline for more detailed studies by commodity experts, nutritionists, and agronomists, working in small teams.

The world frame is designed to provide a frame of control for the regional teams, and also to facilitate investigation in broad terms of the effects of changing basic assumptions concerning capital inflows and foreign exchange earnings vis-à-vis the developed and centrally planned economies. It is envisaged that the world model be evolved, by experiment to the point where it could be fully computerized.

The validity of the approach described, which rests on the decomposition of the world problem to a series of regional models working in an iterative relation with the world model, depends to a large extent on whether a suitable definition of region is possible. If a group of countries show at least potential complementarity in their agricultural patterns, even though their export sectors may at present be strongly competitive in the world markets, the iterative scheme has a good chance of working in the two-stage manner proposed. But the UN subregion of West Africa may have been better from this aspect than some others. The East African subregion for example ranges from Somalia in the north to Basutoland in the south, and the potential complementarity is greater for some of these countries with respect to countries in other UN subregions than with respect to other East African countries. In such a

case it may be advisable to construct an intermediate table for the UN region of Africa and to work within this more general frame. This solution is of course inferior to that of using a more meaningful subregional classification.

Comment

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J. A. C. Brown's paper was prepared in 1965 and presented at a session of the First World Congress of the Econometric Society in Rome in September of that year. Its basic intent was utilitarian. It was intended to provide a framework for the Food and Agriculture Organization's studies preparatory to the Indicative World Food Plan, which was to be completed in time for a major FAO conference in October–November 1967. I became acquainted with the paper, and with Brown, in connection with the First World Congress and with a two-day meeting at FAO to discuss proposed methodology for the Indicative Plan, both in September 1965.

At that time I was serving as chairman of the Planning Committee for the present conference (i.e., the Universities-National Bureau Committee conference on *The Role of Agriculture in Economic Development*). It seemed to me that an elaborated and expanded version of this paper would provide an ideal opening for the present conference and the Committee agreed with me.

Brown's model was used in connection with an FAO pilot study for West Africa early in 1965. However, FAO chose not to use such a tightly integrated framework for its studies of the remaining regions of the world, so there was no pressing reason for refining the model beyond its state as of September 1965.

Even so, the Brown model has the virtues of comprehensiveness and consistency. Tentative plans for production, exports, and imports of each agricultural commodity in each world region would confront one another in a closed system. It would be difficult to gloss over prospective surpluses and shortages. Also, each coefficient underlying the demand projections could be varied within a reasonable range to observe its effect on commodity balances and trade.

Brown's model, as befitted the state of the arts in 1965, did not specify the methods by which commodity yields, acreages, and production were to be estimated. These methods would depend upon the data and research bases available in each world region or subregion. They might even depend on the expertise of the particular team of experts surveying a given region, as several different teams were to be used in making the regional surveys preparatory to the Indicative World Food Plan.

My appraisal is that Brown's model was well designed for its purpose. If FAO had used this framework with the help of Brown or anyone else of equivalent competence and realism, the 1965 version of the model would no doubt have been refined and improved. We should also have had a consistent set of data in a format that invited further testing, manipulation and (hopefully) cumulative improvement.

I am in no position to judge whether FAO's decision to use a more eclectic approach in its regional surveys was a wise one, given the considerations of time, personnel, and other constraints it may have faced. In the interest of clarifying certain opportunities for improved policy-oriented models of world economic development emphasizing agriculture, I am contributing the following paper.